MORPHOGENETIC DIFFERENCES BETWEEN NICOTIANA ALATA AND N. LANGSDORFFII AS INDICATED BY THEIR RESPONSE TO INDOLEACETIC ACID

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Introduction

An unusual opportunity for the application of the present knowledge of hormones to the investigation of morphogenetic differences between two closely related species is afforded by *Nicotiana alata* and *Nicotiana Langsdorffii.* The flowers of the two species are similar, but the difference in the size of the corolla parts suggests a possible interpretation in terms of hereditary response to growth substance. One of the chief differences lies in the constricted part of the corolla-tube (pl. 25, fig. 1). In *N. alata* its length is at least fifteen to twenty times that of *N. Langsdorffii,* whereas the whole corolla in the former is only four or five times the length of the latter. The epidermal cells of the tube of *N. alata* are extremely long; those of *N. Langsdorffii,* relatively short.

The work on several known genetic dwarf races of corn by van Overbeek ('35, '38) indicates that the varietal differences are due to genetic differences which regulate production, use, and inactivation of auxin. The experiments on *Epilobium* hybrids by Schlenker and Mittman, cited by Went and Thimann ('37), suggest this same relationship. If this hypothesis holds true for species of *Nicotiana* and the differences between them are due to differences in amount of hormone produced, then auxin should prove to be a limiting factor in *N. Langsdorffii* and its application to the corollas of this species should then cause an increase in size. If differences are due to differences in ability to use growth substance, then auxin should be a limiting factor in *N. alata* and additional amounts should increase growth, whereas *N. Langsdorffii* would probably inactivate the hormone. On the supposition that the fundamental morphological distinctions between the two species are linked to genetic differences in ability to use or produce hormone, the following experiments were carried out.

Materials

Nicotiana alata Link & Otto and *Nicotiana Langsdorffii* Wienm. belong to a phylogenetic unit within the genus referred to by Priscilla Avery ('38) as the "alata-group." This is a group appearing to have a center of distribution in the Brazilian and northern Argentine area, and its members possess many morphological and genetic characters in common. The two above species have the same chromosome number and hybridize readily, hybridization occurring at times in nature.

Seeds of both species were planted in the greenhouse October 25, 1938, and flowered from February to April, 1939, inclusive. Flowers and stems were given similar treatment throughout the course of the experiment. One per cent and .5 per cent lanolin pastes were prepared by dissolving the indoleacetic acid (Eastman & Mallinckrodt) in melted lanolin. They were then stored in dark bottles. Due to the instability of indoleacetic acid in water solution the method of Brannon ('37) was followed, the auxin being dissolved in 95 per cent alcohol at a concentration of 4 mg./cc. The water solutions were prepared from this as needed. The alcohol was redistilled to insure purity. Tap water was used in all tests. Water controls were run as checks on solution treatments and pure lanolin controls were used for comparison with the hormone-containing lanolin pastes.

Experimental Methods and Results

RESPONSE OF FLOWERS TO INDOLEACETIC ACID

Flowers were studied first as they present the most striking difference between the two species. Four parts of the corolla were recognized; (1) the slender constricted portion of the tube to which the stamens are attached, herein called the tube,

(2) the widened part of the tube, herein called the throat, (3) the gibbous ring of the throat, and (4) the limb (fig. 1). These

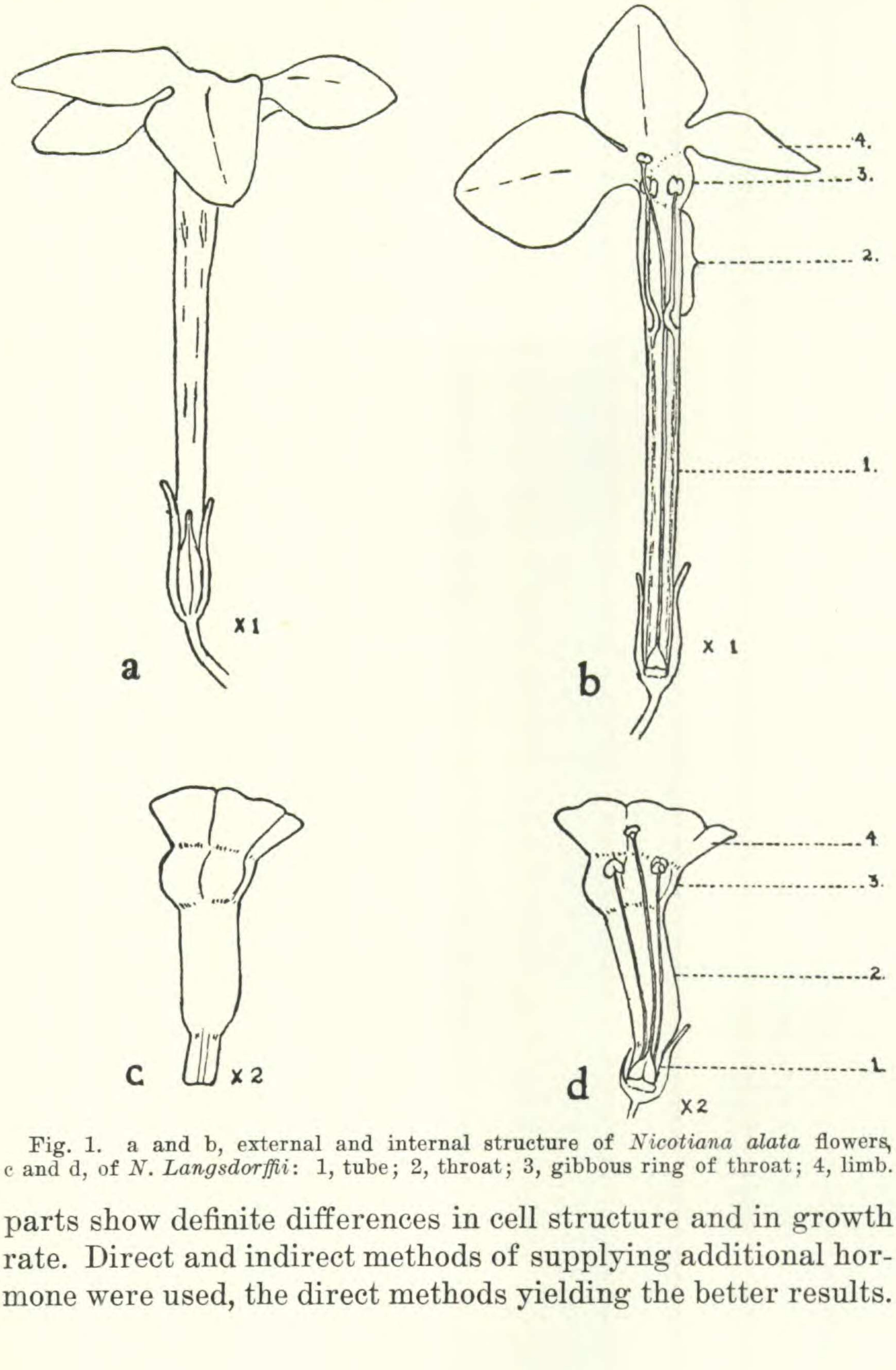

Fig. 1. a and b, external and internal structure of *Nicotiana alata* flowers, c and d, of *N. Langsdorffii*: 1, tube; 2, throat; 3, gibbous ring of throat; 4, limb.

parts show definite differences in cell structure and in growth rate. Direct and indirect methods of supplying additional hormone were used, the direct methods yielding the better results.

Lanolin paste was applied to the tube and throat of both species. In one series of tests one side was smeared with pure lanolin as a control, and the other side with 1 per cent indoleacetic acid-lanolin paste, the two pastes not being permitted to touch. The calyx was cut away in both species to allow the paste to extend to the base of the tube. As a check, untreated flowers of the same size also had the calyx removed. The corollas of *N. alata* ranged from 68 to 75 mm. in length at the time of treatment; those of *N. Langsdorffii,* from 13 to 17 mm. After the corollas were removed from the plant, a narrow strip from each treated side was measured.

As indicated in table I and pl. 25, fig. 2, growth in *N. alata* was stimulated on the side receiving the hormone, a negative curvature of that side resulting within 48 hours. *N. Langsdorffii* showed no perceptible response (table II). If *N. alata* was treated when too mature, no curvature resulted; if too young, the side receiving the hormone became fluted and bulged, but growth in total length was inhibited. The throat showed only slight response or none. Untreated flowers which had only the calyx removed showed no curvature or other alteration. Growth was accelerated regardless of which side of the tube

TABLE I

EFFECT OF APPLICATION OF HORMONE PASTE AND PURE LANOLIN TO OPPOSITE SIDES OF *N. ALATA* COROLLAS

Length of tube		Increment of treated side over untreated	
Side receiving pure lanolin	Side receiving 1% indoleacetic acid-lanolin paste	Length	Percentage
mm.	mm.	mm.	%
46	53	7	15.2
44	50	6	13.6
51	58	7	13.7
47	55	8	17.0
42	49	7	16.6
49	55	6	12.2
48	53	5	10.4
42	48	6	14.3
44	50	6	13.6
33	42	9	27.3
Av. 44.6	51.3	6.7	15.0

received the hormone. Curvature resulted whether or not pure lanolin was applied to the side opposite the one treated with hormone.

TABLE II

COMPARISON OF TUBE LENGTH AFTER TREATMENT OF OPPOSITE SIDES WITH HORMONE PASTE AND PURE LANOLIN *

Species	Length of tube		Increase of treated side
	Side receiving pure lanolin	Side receiving 1% indoleacetic acid-lanolin paste	
	mm.	mm.	%
N. alata	44.9	50.4	12.2
N. Langsdorffii	3.0	3.0	0.0

* Results are the average of 25 flowers each.

In a second series of tests two corollas of the same size were selected and lanolin was applied all around the tube. The controls received pure lanolin, the experimental flowers, 1 per cent indoleacetic acid-lanolin paste. In *N. alata* it was necessary to use two flowers from the same plant, as corolla-tubes maturing on a given parent at any time vary in length only two to five mm., whereas those from different parent stocks vary as much as 20 mm. (table III). The shorter the time elapsing between flower development, the less the variation on a given plant. The last flowers on a branch tended to be definitely smaller. In *N. Langsdorffii* the flowers varied so slightly that they could be taken from any plant. The calyx was again removed. The size of the flower at the time of treatment was the same as in the preceding test. Results with *N. alata* were not as clearly defined as in unilateral treatment but nevertheless indicated the same sensitivity to auxin found in the first test (table IV). Very young flowers of *N. alata* did not give consistent results; those nearly mature did not respond at all. Difficulty arose in finding suitable pairs of flowers of this species. As before, the tube and throat of *N. Langsdorffii* showed no measurable response (table V), except a similar inhibition of growth with both treatments.

TABLE III

VARIATION IN LENGTH OF UNTREATED *N. ALATA* COROLLA-TUBES

Plant no.	Number of tubes measured	Longest	Shortest	Average	Range of variation per plant
		mm.	mm.	mm.	mm.
1	10	55	50	52.1	5
2	7	55	50	52.3	5
3	10	47	45	46.3	2
4	7	54	50	52.5	4
5	10	56	53	54.2	3
6	8	46	42	45.0	4

TABLE IV

LENGTH OF COROLLA-TUBES AND THROATS OF *N. ALATA* TREATED ALL AROUND THE TUBE WITH HORMONE PASTE

Pair no.	Pure lanolin control		1% indoleacetic acid-lanolin paste	
	Tube	Throat	Tube	Throat
	mm.	mm.	mm.	mm.
1	45	25	47	25
2	52	23	55	23
3	51	22	54	24
4	53	23	55	23
5	53	24	54	24
6	48	24	55	24
7	49	27	54	29
8	42	30	47	30
9	32	20	39	24
10	52	23	55	
Average	47.7	24.1	51.5	25.0

TABLE V

LENGTH OF PAIRS OF COROLLA-TUBES FOLLOWING TREATMENT ALL AROUND THE TUBE*

Species	Pure lanolin	1% indoleacetic acid-lanolin paste	Increase
	mm.	mm.	%
N. alata	47.6	51.5	8.2
N. Langsdorffii	3.0	2.9	-3.0

* Results are averages from 25 flowers.

Immature flowers were cut off and floated in a solution of 10 mg. indoleacetic acid per liter of water and measured after 48 hours. A comparable group was floated in water. *N. alata* corollas of various length were tried, but the only consistent results were that they seemed to mature more slowly than the water controls. In preliminary tests with *N. Langsdorffii* those corollas 17 to 19 mm. in length seemed to show definite increase in limb length and spread, also more blanching than average; a few plants normally showed this tendency. Repetition with two separate groups of fifty corollas each showed this increase in limb length to be consistent (table VI). The corollas had been sorted in pairs of equal size at the beginning of the experiment and one of each pair placed in hormone solution and one in water. If there was any variation in size, the water received the larger flower.

TABLE VI

LENGTHS OF PARTS OF COROLLA OF *N. LANGSDORFFII* FLOATED 50 HOURS IN HORMONE SOLUTION*

Treatment	Limb	Tube and throat	Total length	Limb spread†
	mm.	mm.	mm.	mm.
10 mg. indoleacetic acid/liter	5.0	23.1	28.1	15–17
Control	4.1	22.0	26.1	11–13

* Results are the average of 50 flowers.
† Ten largest only were measured.

Among the various indirect methods of supplying hormone to the flower was the application of lanolin paste to the stem below the inflorescence. When 1 per cent paste was used, there resulted an inhibition of flower buds above the treated area in *N. alata,* a slight inflation of the calyx being followed by yellowing and abscission. The growth of buds on older stems was not immediately checked, but the younger buds were affected. *N. Langsdorffii* showed definite local response such as stem curvature, but this self-fertile species matured seeds as usual above the treated area unless the plants were given extremely heavy doses when very young.

On either side of the stem below the inflorescence strips one-half inch in length were coated with the .5 per cent lanolin paste at three-day intervals. Not a sufficient number of plants of *N. alata* were treated to give conclusive results in a species as variable as this. However, tube growth seemed to be somewhat accelerated and the average length of the tubes was somewhat greater than in the untreated flowers. Repeated applications often led to an inhibition of growth above the treated area as with the more concentrated paste. The frequent use of pure lanolin caused no change. Two branches of each of several plants were treated, one receiving the hormone, and one pure lanolin. After a time the former ceased to grow but the latter continued development, thus indicating that the hormone was very probably the cause of the inhibition. *N. Langsdorffii* showed no response to the .5 per cent lanolin paste except slight local curvature if application was uneven.

Cut inflorescences of both species were placed in water solution of indoleacetic acid and also in water. To be sure that results were due to the hormone in solution and not to the alcohol which was used to dissolve it, equal amounts of alcohol were added to both. Neither showed any appreciable acceleration of flower size, but a concentration of 10 mg. per liter caused inhibition of floral development in *N. alata*. Solutions of 5 mg. per liter or less resulted in neither bud inhibition nor noticeably larger flowers. The flowers of *N. Langsdorffii* were the same size in the water control and in the auxin solution. While both species keep well when cut, in hormone solution they seemed to keep longer than in water.

In an effort to determine the source of growth substances, styles and stigmas were removed from the flowers of both species while they were still young. In *N. Langsdorffii* it is a simple procedure to open the limb with fine forceps and to reach the style without damaging the corolla and stamens. Except with almost mature specimens of this species the flowers drop off before reaching maturity, usually within 24 to 48 hours after removal of the style. The younger the flowers, the sooner they drop off. The treated flowers were marked with blue on the calyx. Recent experimentation by Bonner and English ('37, '38) has indicated the formation of the wound hormone, traumatin, as a result of tissue damage. This could be a source of error, especially in *N. alata*, as it was impossible to reach the pistil with available instruments without damaging the corolla and stamens. Therefore, in some of the flowers the limb was cut away with a sharp razor. In half of these the stigma and part of the style were removed; in the other half they were left intact. Even with the limb removed, it was difficult to reach the pistil. The cut inflorescences were then placed in water and covered with a bell jar to reduce transpiration. Previous experience had shown that the flowers on cut inflorescences matured satisfactorily in water. Those flowers with pistils removed tended to develop shorter tubes or to drop off, but some grew normally. On the plants, ten young corollas of various sizes were slit down one side of the tube and the style severed close to the base; others were slit, but the style left intact as controls. Both sets usually matured and the controls were then measured and examined for style injury. Again results were not consistent, but the flowers with severed styles tended toward shorter tubes; the throats were not greatly affected. Curvature toward the injured side developed in both.

Normal cell structure and growth rate of the corolla parts were studied as an aid in understanding the reactions of these parts to indoleacetic acid. Two series of ten corollas of each species were marked off into tube, throat, gibbous ring of throat, and limb by means of fine blue lines. These parts were measured at 24-hour intervals until growth stopped. In *L. Langsdorffii* measurements of growth were started as soon as the corolla parts could be easily distinguished; in *N. alata,* when the corolla was approximately 35–45 mm. in length. Figure 2 represents graphically measurements for the five days preceding full development in *N. alata* and the four days preceding full development in *N. Langsdorffii.*

Cell structure was not studied in detail, but a microscopic examination of the epidermal cells of the various parts was made in order to compare their size and shape. In *N. alata* the epidermal cells of the corolla-tube are extremely long and are similar to those of the *Avena* coleoptile in general shape (fig. 4A), whereas in *N. Langsdorffii* they are comparatively short, almost isodiametric (fig. 4B). As the growth rate of the

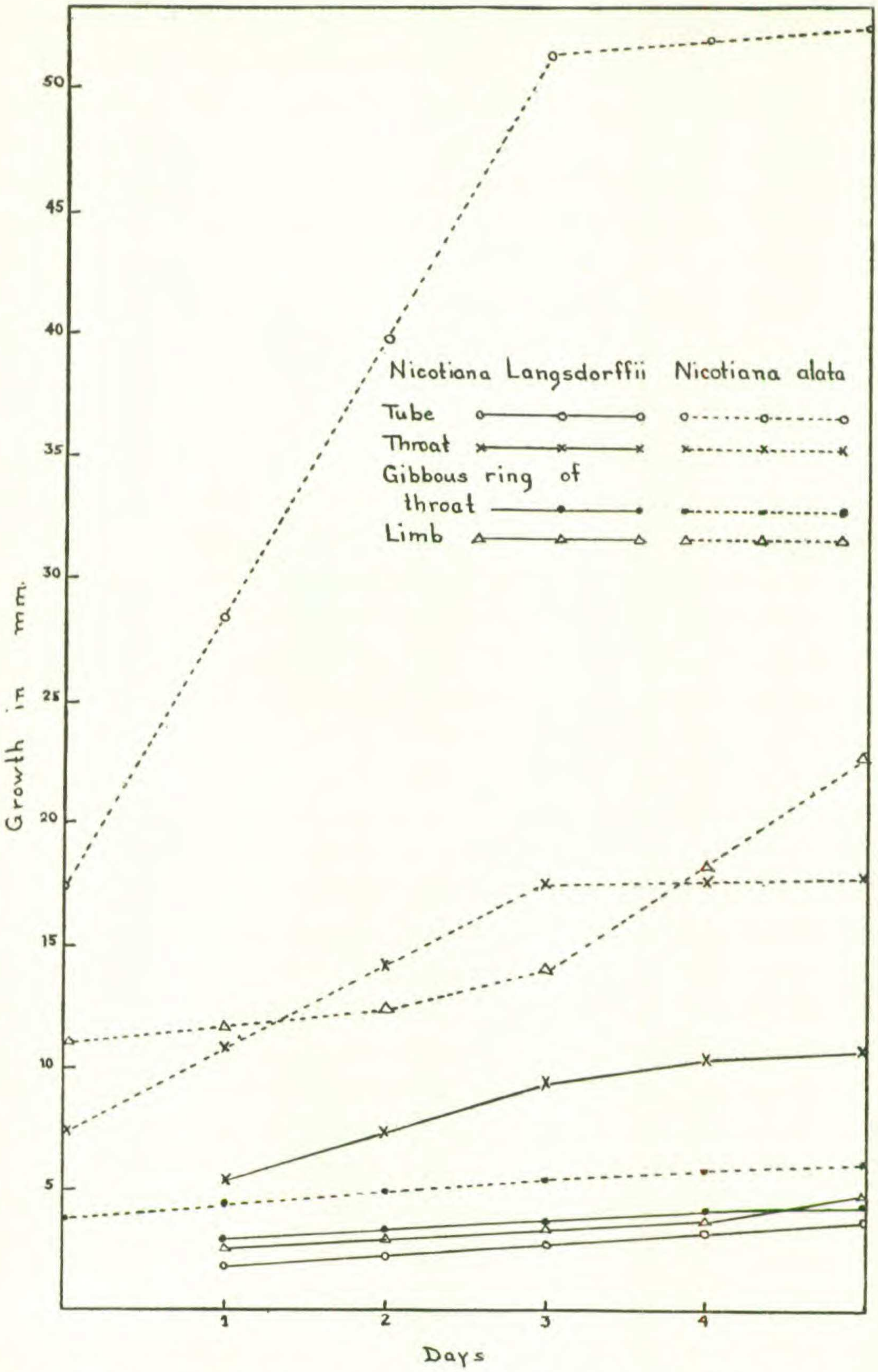

Fig. 2. Growth rates of corolla parts of *Nicotiana alata* and *N. Langsdorffii*. Results are the means of 15 corollas.

tube of *N. alata* is very rapid and that of *N. Langsdorffii* very slow (fig. 3), a correlation between growth rate and cell elongation is indicated. The cells of the throats of the two species are

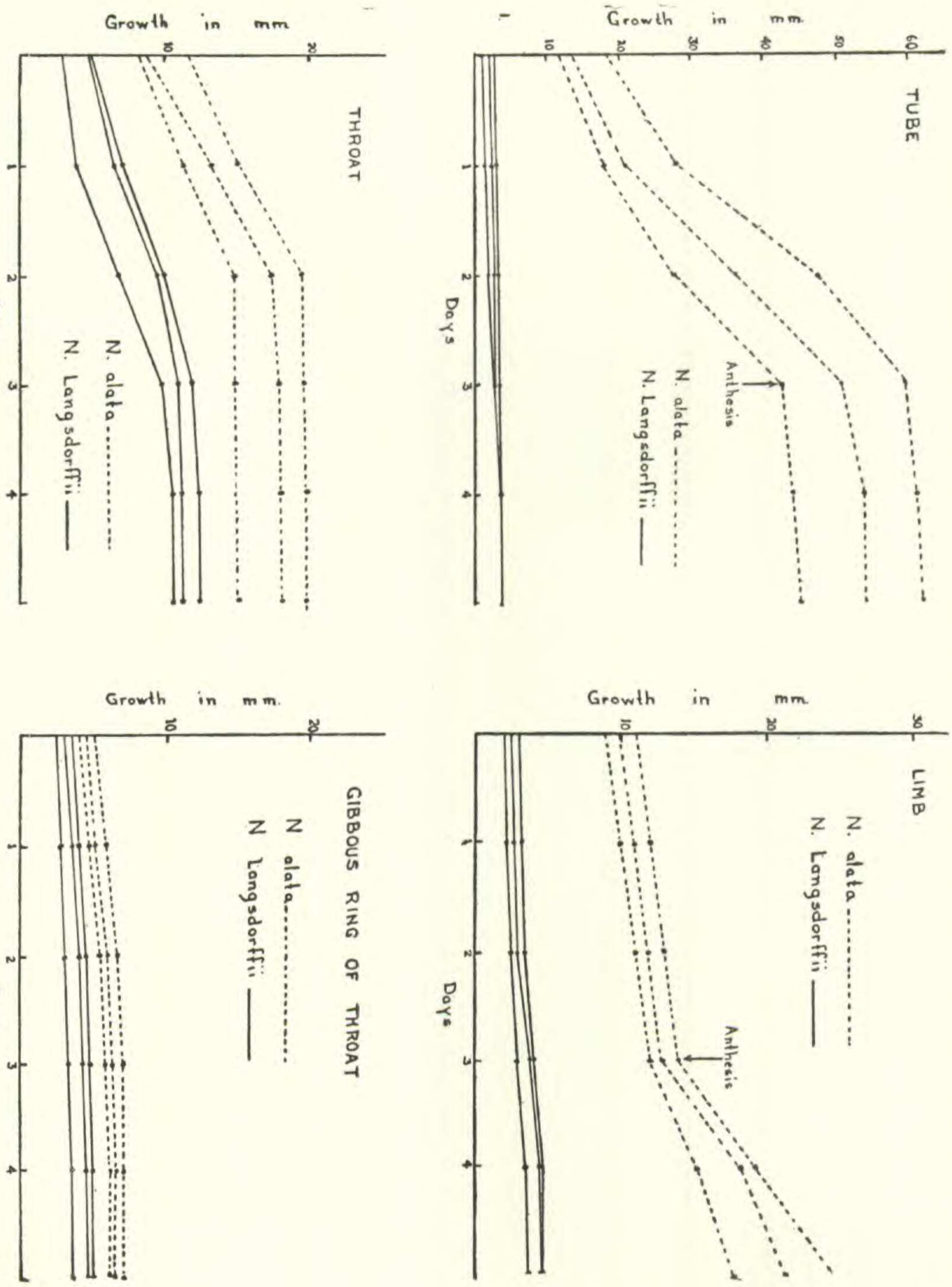

Fig. 3. Growth rates of corolla parts of *Nicotiana alata* and *N. Langsdorffii*. Three typical flowers used for each.

similar in size and shape (fig. 4E, F) and growth rate (fig. 3). They are shorter than those of the *N. alata* tube. In both species the cells of the gibbous ring of the throat show a gradual transition from the longer ones of the throat to the isodiametric cells of the limb (fig. 4C). The two species also have similar growth curves (fig. 3). Many stomata are present.

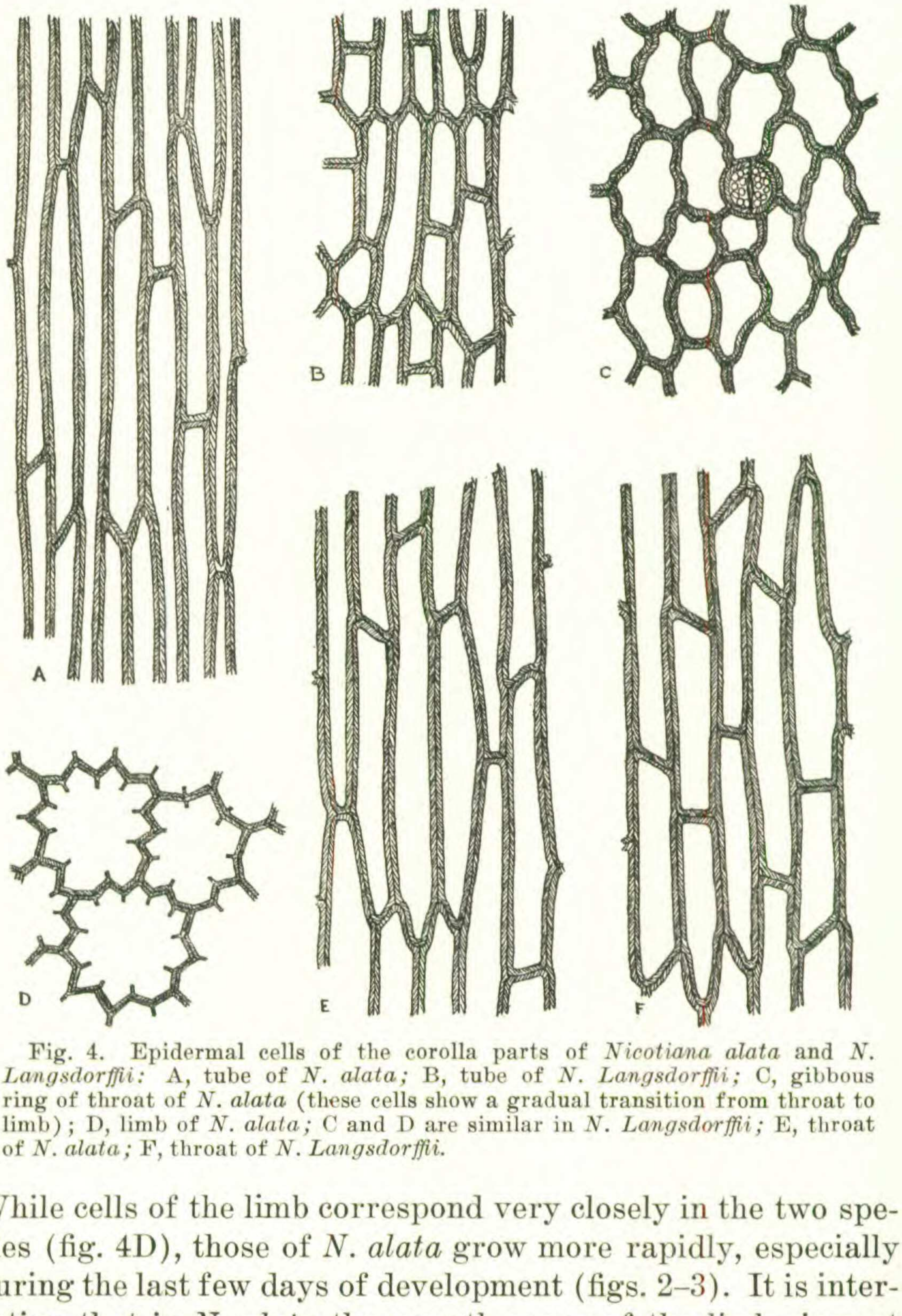

Fig. 4. Epidermal cells of the corolla parts of *Nicotiana alata* and *N. Langsdorffii*: A, tube of *N. alata*; B, tube of *N. Langsdorffii*; C, gibbous ring of throat of *N. alata* (these cells show a gradual transition from throat to limb); D, limb of *N. alata*; C and D are similar in *N. Langsdorffii*; E, throat of *N. alata*; F, throat of *N. Langsdorffii*.

While cells of the limb correspond very closely in the two species (fig. 4D), those of *N. alata* grow more rapidly, especially during the last few days of development (figs. 2–3). It is interesting that in *N. alata* the growth curve of the limb rises at about the time of anthesis as the tube and throat curves flatten out.

STEM RESPONSE TO INDOLEACETIC ACID

A peculiar curvature of the stem in *N. alata,* apparently resulting from the action of the hormone, suggested a limited study with stems of both species. Young flower stalks were used; old ones in which growth had practically stopped did not respond. If the primary stalk was used, it was cut off 45 to 60 cm. from the tip; secondary ones were of necessity much shorter. These were placed in solutions of (a) 10 mg. of indoleacetic acid/liter, (b) 5 mg./liter, (c) 1 mg./liter, and (d) tap water. Solutions were changed every other day until three or four treatments were given. Then the stems were placed in water which was changed as needed.

With a concentration of 10 mg./liter, *N. alata* showed increased growth on the side opposite the insertion of the leaf in the younger parts of the stem and therefore marked curvature of the stem in the region of the upper leaves (fig. 5). This occurred in from two to five days from the beginning of treatment, the younger stems responding more quickly. At this concentration the flower buds which were nearly mature continued normal development, while the younger buds turned yellow and abscissed (pl. 26, fig. 2). With a concentration of 5 mg./liter, the stem curvature was slight and the flowers matured in the same time as those of the controls (pl. 26, fig. 1). No effect was apparent with weaker solutions, nor with the small amount of alcohol used to dissolve the hormone, $2\frac{1}{2}$ cc. per liter.

While *N. Langsdorffii* also showed curvature with a concentration of 10 mg./liter, it was much less pronounced (pl. 26, fig. 2). The flower buds were not affected.

Roots developed freely from the stem surface of *N. alata* in the region where indoleacetic acid solution had been applied. Both 5–mg. and 10–mg./liter solutions stimulated abundant root production. Stems also developed roots without treatment, but only near to the base, and they were not as numerous as on the treated stems. These results are in agreement with

Fig. 5. *Nicotiana alata*, showing curvature when stem was placed in a solution of 10 mg. indoleacetic acid/liter. Note that curvature is convex opposite insertion of leaf.

those of Stuart ('37) and Pearse ('38), who have found root development accelerated by auxin. According to Brase ('37), failure to produce roots was not overcome in many species by use of synthetic growth substances. This seemed to be true of *N. Langsdorffii,* which did not produce roots either with or without treatment.

As previously mentioned, applications of 1 per cent indoleacetic acid-lanolin paste will induce local curvature of the stems in the treated region in both species. Even with one treatment, roots will finally break through the epidermis in *N. alata.* Inhibition of floral development above the treated area was complete, although branches below matured normally (pl. 26, fig. 3). *N. Langsdorffii* showed no inhibition and no root formation, but matured its flowers and seeds normally in spite of extreme curvature (pl. 26, fig. 4). Growth was checked in this species only when high concentrations were used daily on young stems. External roots did not appear. A concentration of 0.5 per cent indoleacetic acid in lanolin produced the same type of result as the more concentrated paste, but to a less degree. *N. alata* showed gradual inhibition of growth above the treated area; very few roots developed.

Discussion

The response of a plant to additional growth substance is conditioned by its sensitivity and its tendency to inactivate auxin. The curvature of the corolla-tube in *N. alata* following application of indoleacetic acid-lanolin paste indicates that this species has the ability to use additional hormone. This was also suggested by the increase in length of corolla-tubes following application of hormone paste all around the tube. Like the cells of the *Avena* coleoptile, the tube cells of *N. alata* respond readily to growth substance. Microscopic examination indicates that this increased growth in *N. alata* is the result of increased cell elongation rather than division. Cells of this type which in nature elongate rapidly are thought to be often capable of using auxin for further elongation. The short tube cells of *N. Langsdorffii* show no response to hormone with any method used. This indicates a probable inherent lack of ability to utilize growth substance, possibly due to lack of sensitivity to it or to its inactivation by oxidative destruction or enzyme activity. The difference in the tubes of the two species, not only in size but in cell structure and growth rate also, is probably due to the heritable genetic difference in the ability of their cells to respond to growth substance.

The throats of the two species are similar in cell size and growth rate. In neither species did the throat show marked response to addition of growth substance. The limb of *N. alata* grew more rapidly than *N. Langsdorffii* during the last few days of development. The development of the corollas floated in hormone solution possibly gives some insight into the effect of the hormone. Isolated corollas of *N. alata,* in which growth is normally very rapid, showed no increased growth over controls, but both were considerably shorter than normal. Recent work of Alexander ('38) and Stuart ('38) has indicated that one of the effects of hormones such as indoleacetic acid in stimulating growth is the mustering of the food factor. *N. alata* normally grows with such rapidity that the food present in isolated corollas is probably soon exhausted and further growth then limited. *N. Langsdorffii,* which is comparatively unresponsive to indoleacetic acid in other parts of the corolla, shows increased growth of the limb when floated in hormone solution. This tendency was noted also after the application of lanolin paste, although exact measurements were not made. If auxin is considered to be one of the factors necessary for growth, it may be that not enough reaches the limb to allow optimum development and thus it becomes a limiting factor. Perhaps this explains why with direct application these cells are stimulated to increased growth.

Since it is generally the terminal bud which produces hormone, the stigma and style, being considered the possible counterpart of the terminal bud, were removed to study the effect on the flower. That *N. Langsdorffii* flowers wilt and drop off after removal of these parts, unless nearly mature at the time, was considered as evidence that they may control the development of the flower in some way. Went and Thimann ('37) make the general statement that auxin is one of the many factors necessary for the ordinary growth process and that "without auxin, no growth." Absence of auxin may thus account for the lack of development. However, Avery and LaRue ('38) have found that decapitated *Avena* coleoptiles will continue development on agar culture containing food and minerals for as much as six days after all measurable traces of growth substance have been used up. The hormone is therefore probably not a necessity for growth although it does stimulate or "catalyze" it. On the other hand, *N. alata* flowers are often developed after the removal of the stigma and part of the style, although with shorter tubes than usual. Growth is limited, but not often stopped. This may be due to inhibition caused by the wound hormone, traumatin, or it may be that some other source supplies the growth substance. It is also possible that all of the long style was not removed and that there is a "regeneration of a physiological tip"; or that the part of the style remaining still produces enough auxin for limited growth.

A study of the flowers of the two species seems to indicate that their differences lie in genetic differences in response to hormone, *N. alata* being sensitive to it, *N. Langsdorffii* lacking in ability to use it or inactivating it.

When cut young flower stalks were placed in hormone solution, the "unphysiologically" high concentration of indoleacetic acid—10 mg./liter—was carried upward in the transpiration stream (Hitchcock and Zimmerman, '35). This is not in opposition to the usual concept of polarity expressed by Went and Thimann ('37). The curvature of the young stems was brought about by greater growth on the side opposite the leaves. The lessened growth in the region of the leaf insertion may have been caused by a lower concentration of hormone in the stem owing to its passage into the leaf. Old stems show no curvature because the aging of the cells renders them unresponsive. *N. alata,* with characteristic sensitivity and good transport facilities, curved strongly, the degree of curvature depending upon age of the cells and concentration of the hormone. In the cut stems of *N. Langsdorffii* the hormone was probably likewise carried upward in the transpiration stream, but the resulting slight curvature showed little use of the additional hormone. It is possibly significant that the total height of *N. alata* is greater, 150 to 190 cm., than of *N. Langsdorffii,* 110 to 120 cm. Both species respond to local application of 1 per cent indoleacetic acid-lanolin paste in young stem regions. As this is also an "unphysiologically" high concentration of hormone, unequal application of it stimulates *N. Langsdorffii* locally to marked curvature but no roots appear. Due to the destruction of the hormone in transport or to lack of sensitivity of this plant to it, the flowers and other parts were not affected. *N. alata* showed similar local curvature of the stem with formation of adventitious roots.

The effects from both lanolin application and solution treatment are not limited to the stems of *N. alata,* but are extended to the flower stalk. With the concentrations used, growth was completely inhibited and flower buds and upper nodes of the flower stalk were eventually killed. This again seems to indicate that inactivation does not occur in *N. alata,* as a high concentration of the substance apparently reaches the flowers.

Because of the great sensitivity of the cells of *N. alata* to hormone, the concentrations used proved to be toxic to the younger cells. That very young corollas do not respond favorably to applications of lanolin paste might be explained by this fact. The upper tissue is perhaps partly inactivated by the mobilization of food materials in the treated area of *N. alata* as this region responds with the formation of numerous roots; and development of roots requires food material. The differentiation of the tissue to form roots on the stem would possibly interfere mechanically with transport and aid in causing inhibition above the region of application. Cut flower stalks of *N. alata* produced some basal roots without any treatment, but more if treated with 5 or 10 mg. indoleacetic acid/liter. *N. Langsdorffii,* however, produces none under such conditions, thus giving additional evidence that *N. alata* probably is hereditably more able to use growth substance. As is usually true, *N. alata* roots more quickly when treated. It has been suggested by Went ('38, '39) and Cooper ('38) that indoleacetic acid stimulates rooting by causing a redistribution and then an activation of the rhizocaulin already present in the tissue.

Went and Thimann ('37), in the light of the work of Lehman, Hinderer, Schlenker, and others, on *Epilobium* hybrids, suggest that possibly the sensitivity to growth hormone might be determined by the genes; the auxin production, by the cytoplasm. The above results suggest that morphogenetic differences in hormone response probably account for the principal differences between the two species studied.

Summary

1. The corollas and flower stalks of *Nicotiana alata* and *Langsdorffii* were used in studying the role of growth hormones in morphogenesis.

2. The corollas were found to serve as especially favorable material since they follow the same general growth pattern, but differ markedly in cell elongation. Results indicate that *N. alata* generally has greater ability to use additional hormone than *N. Langsdorffii.* The former also is more sensitive and smaller amounts prove toxic to young cells. Corollas of *N. Langsdorffii* give evidence of inactivation of growth hormone except in the limb.

3. Young flower stalks inserted in hormone solution respond by curvature on the side opposite the leaf insertion. The response is much greater in *N. alata* than in *N. Langsdorffii,* and in both species depends upon the age of the stem and the concentration of the hormone.

4. Experiments indicate that many of the principal differences between the two species lie in a genetically controlled difference in their ability to use hormone.

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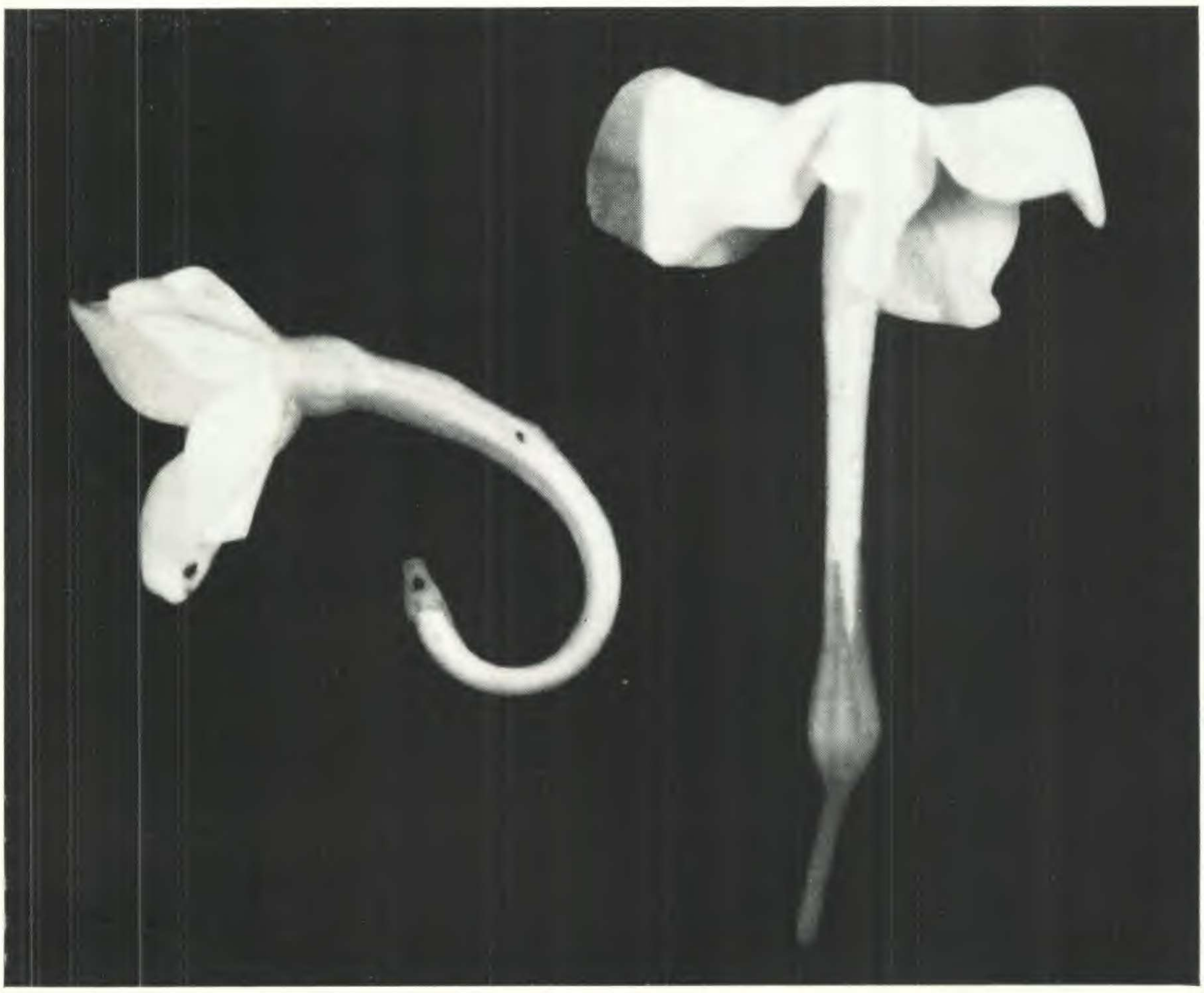
Explanation of Plate

PLATE 25

Fig. 1. At left, inflorescence of *Nicotiana alata;* at right, inflorescence of *Nicotiana Langsdorffii.*

Fig. 2. Curvature of *Nicotiana alata* in response to treatment with 1 per cent indoleacetic acid-lanolin paste. In flower at left, right side of tube had been treated with hormone paste; left side with pure lanolin. Flower at right was untreated.

1



2

NAGEL—NICOTIANA ALATA AND N. LANGSDORFFII

EXPLANATION OF PLATE

PLATE 26

Fig. 1. Stems of *Nicotiana alata* which were placed in a solution of indole-acetic acid. A was treated with a solution of 5 mg./liter; B, with a solution 10 mg./liter. Note greater curvature and bud inhibition in the latter.

Fig. 2. Stems of *Nicotiana* kept in a solution of 10 mg. indoleacetic acid/liter for four days. Left, *N. Langsdorffii;* right, *N. alata.* Note greater bud inhibition and stem curvature in *N. alata.*

Fig. 3. *Nicotiana alata* stem treated with 1 per cent indoleacetic acid-lanolin paste. Note the inhibition of growth and abscission of buds above the treated area. The white spots in the treated area are roots.

Fig. 4. *Nicotiana Langsdorffii* stem showing curvature which followed treatment with 1 per cent indoleacetic acid-lanolin paste. Floral development is not checked and seeds mature as usual above the treated area.

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NAGEL—NICOTIANA ALATA AND L. LANGSDORFFII